Comment on "Resolving the sign ambiguity in $\Delta\Gamma_s$ with $B_s \to D_s K$"

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Abstract:

This is a comment on the recent paper by Soumitra Nandi1 and Ulrich Nierste "Resolving the sign ambiguity in $\Delta\Gamma_s$ with $B_s \to D_s K$", arXiv:0801.0143 [hep-ph].

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In recent paper[1] Nandi1 and Nierste considered the problem of two-fold ambiguity in the quantities extracted from $B_s \to J/\psi\phi$: $\phi_s \Leftrightarrow \pi - \phi_s$, $\Delta\Gamma_s \Leftrightarrow -\Delta\Gamma_s$, $\delta_1 \Rightarrow \pi - \delta_1$ and $\delta_2 \Rightarrow \pi - \delta_2$, where ϕ_s is the B_s mxing phase, $\Delta\Gamma_s = \Gamma_H - \Gamma_L$ is the decay width difference and $\delta_{1,2}$ are two strong phases. In order to determine $sign(\cos\phi_s) = sign(\Delta\Gamma_s)$, one must determine $sign(\cos\delta_{1,2})$. This can be done with naive factorisation[2]. However, the authors argued there is no reason to trust naive factorisation and the sign ambiguity in $\Delta\Gamma_s$ and $\cos\phi_s$ is unresolved.

The authors proposed to resolve the ambiguity by measuring

$$L \equiv b\cos\delta\cos(\phi_s + \gamma)\cos\phi_s$$

and

$$S \equiv b\cos\delta\sin(\phi_s + \gamma)$$

in $B_s \to D_s K$, where b is a positive number by definition, δ is a strong phase and the CKM angle γ is assumed to be well measured externally. By assuming that $|\delta| < 0.2$, the authors concluded that the value of S (L) allows to resovle the ambiguity in $sign(\cos\phi_s) = sign(\Delta\Gamma_s)$.

It should be pointed out that the validity of this conclusion fully depends on the validity of the assumption that $|\delta|$ is small. Without this assumption, the value (also sign) of $\cos\delta$ is basically unconstrained, therefore both S and L are allowed to take a large range of value, making it very difficult to resolve the ambiguity in $sign(\cos\phi_s) = sign(\Delta\Gamma_s)$.

As we know, $\delta \sim 0$ is a result of naive factorisation argument[3]. A natural question to ask is: if we are not prepared to trust naive factorisation for $B_s \to J/\psi\phi$, why should we trust it in the case of $B_s \to D_s K$? This means using S or L alone is insufficient to determine the sign of $\Delta\Gamma_s$ beyond doubt.

Fortunately, the authors also suggested it is possible to combine S and L to eliminate the dependence on δ:

$$\tan(\phi_s + \gamma) = \frac{S}{L}\cos\phi_s.$$

This allows to determine ϕ_s in an unambiguous manner. As seen in Fig. 1, there is a two-fold ambiguity in ϕ_s with $B_s \to J/\psi\phi$ and an up to eight-fold ambiguity in ϕ_s with $B_s \to D_s K$. If the true value of ϕ_s is 0.1 and measurement errors are small enough, then all the discrete ambiguity can be lifted by combining the two channels.

References

[1] Soumitra Nandi1 and Ulrich Nierste, arXiv:0801.0143 [hep-ph].

[2] I. Dunietz, R. Fleischer and U. Nierste, Phys. Rev. D 63, 114015 (2001).

[3] R. Fleischer, Nucl. Phys. B671, 459 (2003).

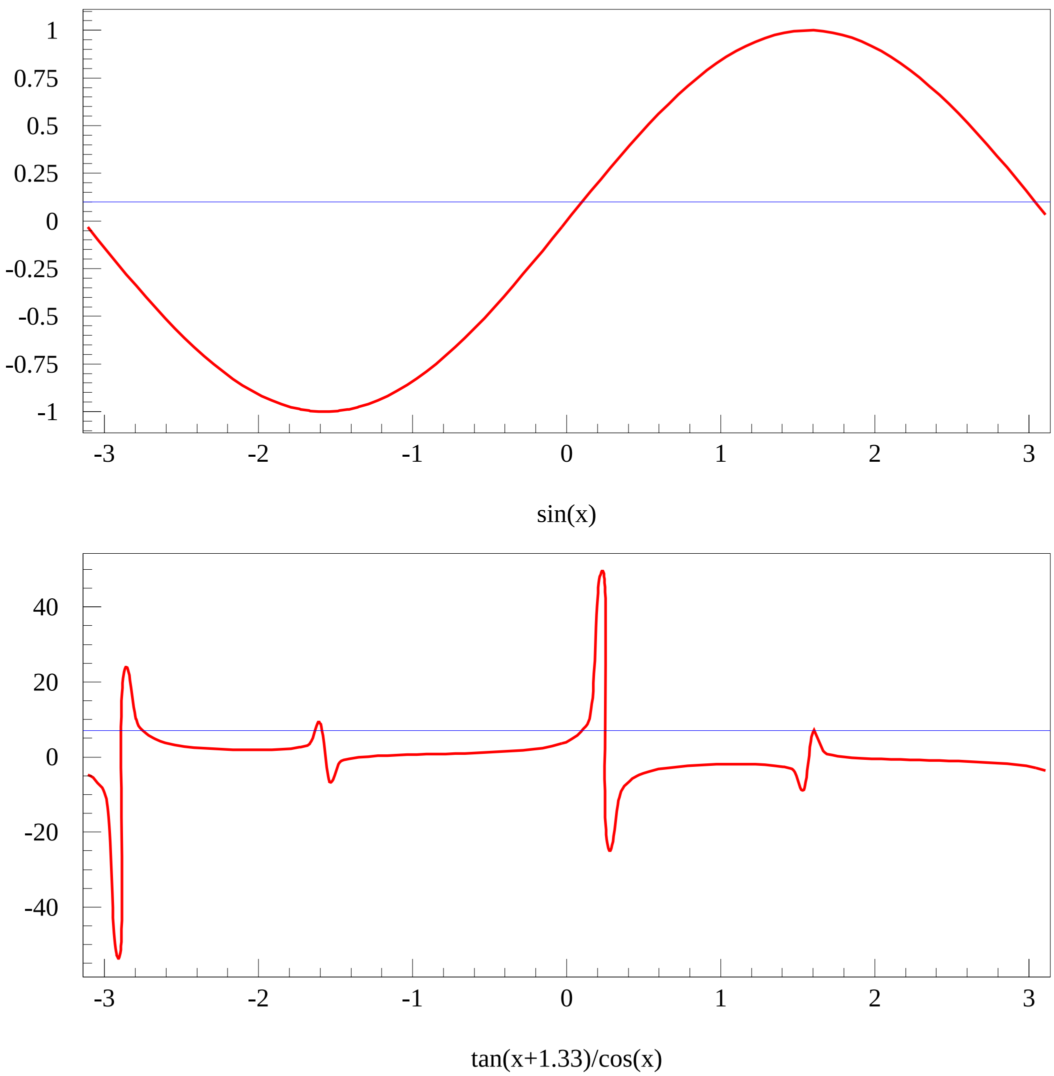

Figure 1: Top: red line for $y = \sin(\phi_s)$ from $B_s \to J/\psi\phi$, blue line for a measurement of y corresponding to $\phi_s = 0.1$; bottom: red line for $y = \tan(\phi_s + \gamma)/\cos\phi_s$ from $B_s \to D_s K$ with $\gamma = 76^{\rm o}$, blue line for a measurement of y corresponding to $\phi_s = 0.1$. No easurement error is taken into account.